Documentation is an essential component of conservation programs, and it involves the collection and organization of the body of information acquired during the project. In the Last Judgment mosaic project, information was collected during the preliminary investigation, scientific research, and treatment phases and continues to be collected during monitoring and maintenance. Documentation can be divided into four types: historical, technical, current condition, and treatment. The data are preserved in written, graphic, and photographic form.

**Historical documentation** is the collection of written and visual information concerning the history of the mosaic and its context. It includes archival records, writings and reports on previous interventions, and as historical photographs or sketches of St. Vitus Cathedral and the mosaic. This documentation was one of the first steps toward understanding the significance and cultural values of the mosaic. For example, the historical records revealed the influence of Charles IV and Italian art on the creation of the mosaic.

The other important objective of historical documentation in this project was to trace the mosaic's history from its construction to the present day. The visual renderings (drawings, sketches, and photographs) of the mosaic make it possible to establish this chronology (see chap. 7).

**Technical documentation**, that is, the record of the mosaic's physical and conservation history, is an essential tool for understanding the causes of its deterioration. The archival record, for example, showed that it was necessary to clean the Last Judgment mosaic only one hundred years after its creation and several more times after that. This tells us that corrosion and legibility are old problems and that the deterioration was most likely related to the composition of the original medieval glass, exacerbated in recent times by air pollution and other environmental conditions.

Documentation of the mosaic's current condition involved recording signs of its conservation history that are still visible: the original material, construction technique, evidence of past intervention, and the type and distribution of deterioration.$^1$

**Treatment documentation** is the collection of information on treatment, methods, and materials. Some of the interventions, such as cleaning of the corrosion products and the coating application, were carried out on the entire mosaic glass surface. Therefore, these interventions were described in written form rather than graphically.

**Recording Techniques**

The first documentation step typically involves photographic documentation to record the condition of the mosaic and to plot various kinds of information observed during the phases of the project. The team anticipated three significant phases of conservation:

1. Before treatment (mosaic covered with corrosion layer);
2. After cleaning (mosaic cleaned and all colors exposed); and
3. After treatment (mosaic regilded and coated).

The photographic and graphic documentation was planned accordingly. All information was collected or transformed in digital form to enable quantitative evaluation and
interpretation to enable overlapping (fig. 1) and comparison of the three different situations. ²

The phenomena recorded graphically included condition and previous interventions and current intervention (see table 1). ³ The graphic records are in digital form. Figures 2 through 6 are examples of these records.

**General Description of the Mosaic and Its Iconography**

The Last Judgment mosaic is located on the south portal of St. Vitus Cathedral (see Introduction, fig. 1). Thermographs of the facade taken during the project show the presence of a closed-up window underneath the central part of the mosaic (fig. 7). The presence of this window, already revealed in the nineteenth century when the mosaic was detached, FIGURE 1 Overlapping of images of the central panel before cleaning, after cleaning, and after regilding. By Rand Eppich.

**TABLE 1 Information Recorded in Graphic Form**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Level of corrosion: Corrosion was categorized as light, medium, heavy, and forming a crust. Information about corrosion had to be collected and recorded before cleaning.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traces of original gilding: Areas with original gold. Due to the glass corrosion process, the mosaic had lost almost all traces of the original gilding.</td>
<td></td>
</tr>
<tr>
<td>Cracks: Location of fractures in the mosaic.</td>
<td></td>
</tr>
</tbody>
</table>

**Previous Interventions**

Borders of sections detached in the nineteenth century: The mosaic was detached from the wall in 1890 because of the condition of the plaster. The mosaic was then repaired and reinstated in 1910, and many new tesserae were placed along the edges of the detached sections. After cleaning, the outlines of the detached sections were visible.

Reintegration with tesserae: Throughout its history, different areas of the mosaic underwent a variety of repairs and reintegration. The restored areas of the mosaic reintegrated with mosaic tesserae were divided into four categories:

1. All new tesserae.
2. Majority of new (nineteenth- and twentieth-century) with few original tesserae.
3. Mixture of original and new tesserae.

Plaster reinforcement of the original setting: Areas where plaster was applied to stabilize loose original tesserae without removing them.

**Current Interventions** *

Fills: Lime-based fills of cracks and losses present but very sporadic.

Test areas: Area of the mosaic where protective coating and cleaning treatment was tested before its implementation.

* The conservation team performed cleaning and coating on the entire mosaic with the exception of the parts made of stone. Therefore, these types of interventions were not recorded graphically.
FIGURE 2 Graphic documentation: distribution of the different types of glass tessera corrosion. By authors, with Rand Eppich and Irene Sen.
FIGURE 3 Graphic documentation: distribution of the different types of glass tessera gilding. By authors, with Rand Eppich and Irene Sen.
FIGURE 4 Graphic documentation: distribution of the different types of previous interventions (1910).

By authors, with Rand Eppich and Irene Sen.
FIGURE 5 Graphic documentation:
distribution of the different types of
previous interventions (1910) and
reintegration with tesserae. By authors,
with Rand Epich and Irene Sen.
FIGURE 6 Graphic documentation: distribution of the condition of the mosaic in 1997 and intervention carried out as part of the GCI–Prague Castle project. By authors, with Rand Eppich and Irene Sen.
indicates that the plan to construct a mosaic on this wall was
developed after 1367, the year this portion of the cathedral
was completed.

The mosaic consists of three panels (see pls. 3–9). In the
middle panel, Christ as supreme judge is seated on a
rainbow inside a mandorla surrounded by angels. Six patron
saints of the kingdom of Bohemia kneel below him. An
inscription band separates the kneeling King and Holy
Roman Emperor Charles IV and his fourth wife, Elizabeth,
from the main motif. On the left panel, the Virgin Mary and
six apostles intercede for the resurrected, who are being
helped from their graves by angels. On the right panel, St.
John the Baptist and six other apostles are interceding
while Archangel Michael raises his sword and devils lead
the damned into hell. The mosaic is framed at the top by a
decorative border fragment with a vera icon and at the
sides, by six narrow strips with acanthus motifs set in the
grooves of the tall pinnacles architecturally dividing the
mosaic.

TECHNICAL DOCUMENTATION

Technique Used to Make the Mosaic
The mosaic was built on a wall made from stone blocks (see
fig. 8 for original stratigraphy). The surface of the stone was
keyed to ensure good adhesion of the first layer of plaster.
Double-hooked iron nails, approximately 18 cm long and
4 mm thick, were hammered between the stones and secured
with lead. These nails were placed at intervals of approxi-
mately 37.5 cm. One of these nails is still embedded in the
wall under the ledge, where the previous wall finish is also
still apparent (fig. 9, 10). Wires were stretched between the
nails in a crisscross and diagonal fashion to create a mesh
net.4 A lime-based plaster, 8 to 12 mm thick, was applied on
this wall and wire net. The plaster was leveled with a trowel
and roughened with irregular nicks; then the artist drew a
rough outline of the artwork on this surface. The mosaic
artist tightly embedded glass tesserae and pebbles, according
to the sketch, into an additional layer of fresh fine mortar.
The mortar was gradually added in patches while the mosaic
was created, similar to the patches of plaster, or giornate,
applied for a fresco wall painting. Most of this upper layer of
pink-colored mortar has been preserved and is visible
between the tesserae. This mortar is made of lime, sand, and
powdered brick. Laboratory testing has also confirmed the
presence in small amounts of egg white.5

The current stratigraphy of the mosaic plaster is the
result of the detachment and repositioning of the mosaic on
the wall facade, a treatment carried out by Förster in 1910
(see fig. 9). Unlike the original mounting, the mosaic and its
base plasters do not protrude from the facade but are flush
with the wall's surface. Before repositioning the mosaic on
the south facade of the cathedral, Förster had the stone sur-
facet carved out to create the space to embed the mosaic deep
in the wall. This intervention was done to prevent water
from running over the mosaic and to avoid a new detach-
ment problem. A rough cement plaster, made from river

FIGURE 7 Thermographs of the
mosaic’s facade showing the presence
of the closed-up window. By Ing. Svoboda
and M. Martan.
sand with pebbles in a 1:1 ratio, was first applied to the stone wall. The mosaic panels were reinstalled into this base with the help of a fine mortar made of lime, cement made from fine sand, and brick dust.

**Glass Tesserae** The mosaic is composed mainly of colored glass tesserae in many shades. The dimensions and shapes of the tesserae vary; however, their exposed area rarely exceeds 1 cm². The background tesserae are mostly in the shape of an irregular prism or truncated pyramid with an almost square front face. Most of the tesserae are less than 8 to 10 mm thick. To depict fine facial expressions, hair, or wings, smaller tesserae of various shapes were used. Tesserae with narrow rectangular front faces are used as lines in contours, as strands of hair, or as feathers in the wings (see pl. 19).

During the GCI-Czech project, after removal of the corrosion layer conservators conducted a close examination of the mosaic and identified a total of twenty-five colors (excluding gilded tesserae and stones). In the 1950s, following the first serious analytic work on the mosaic, thirty or
The mosaic is made with several types of colored glass, and at times it is difficult to clearly differentiate the color. Some tesserae have just slightly different shades of color and should not be considered separate colors but the result of small differences in preparing the same batch of glass, for example, imprecise measuring of ingredients, the addition of common impurities and natural variability of raw materials, or the common volatility of physical conditions during the glass melting process in medieval furnaces. Results from the same recipe often must have varied from batch to batch, and hue variation can be observed even in the glass of a single tessera. This color instability in glass pastes, prepared according to identical recipes, probably produced an entire range of mossy brown hues or similar brownish hues of seedy glass tesserae, which the artist used to shape the lower section of the background.

An example of significant optical difference can be seen in the blue originally gilded tesserae. These tesserae are either opaque, in a color similar to dark Parisian blue, or very transparent glass tesserae, in a deep ultramarine color. Both these variations of blue glass are present side by side on the originally gilded background. Underneath the gold, these differences would have not been noted. We can therefore assume that different tones of blue were not intentional.

Molten glass from the pots was formed into flat sheets or cakes of the required thickness. From these cooled cakes of colored glass, tesserae were then chipped off with a small hammer. The thickness of tesserae varies, although it is generally about 6 to 9 mm. With the estimated average density of medieval glass being 2300 kg/m³, a glass sheet 7 mm thick and covering roughly 85 m²—the original size of the mosaic—would weigh approximately 1350 kg. Certainly it was necessary to produce at least this amount of glass to create the tesserae. This estimate does not take into consideration seams or the waste produced during cutting of the tesserae. The waste was probably added into the next batch, and thus significantly less glass could be used. However, this would not actually decrease the number of pots of glass needed for melting. If the estimated weight of glass from one pot is 25 kg, at least fifty-five pots would have to be melted to produce a sufficient amount of glass. If a great deal of waste was produced during cutting of the tesserae, more batches would need to be melted. Thus tesserae in the most frequently occurring colors could not be produced in one batch.

If we estimate the area of red tesserae in the background at 14.5 m² and the area of blue tesserae in the background at 13 m², it would mean that at least nine batches were needed for the red glass and eight batches for the blue.

**Gilded Glass Tesserae**  The gilded tesserae were manufactured by a classic method known for hundreds of years. Alcohol, or limewater, was applied to the cake of cooled, (often) colored glass, and then the surface of the glass was covered with gold leaf. The entire cake was inserted into the furnace on a pan shovel to bake, and a thin layer of transparent glass was added on top by blowpipe. This sandwich was again baked and, still warm, compressed between iron sheets. After it cooled, tesserae were broken off from the cake. The final shades of the gilded tesserae varied according to the color of the base glass.

Gilding is an intrinsic part of the intended aesthetic impact and iconography of the mosaic. The gilded tesserae with red or blue base glass were used for the background of heaven on all three panels. In addition to the background, numerous important details were gilded, such as rays of the aureole in the mandorla around Christ’s body and under his feet, the crowns and jewels of kings and angels, luminous accents on the folds and patterns of some cloaks, the feathers on the wings of angels, and the chains of the devils. The base glass of gilded tesserae of some details is black.

**Stone Tesserae**  Flesh tones and other details are composed primarily of natural stones, usually small quartz pebbles varying from white to red in hue. The reason for using these stones was undoubtedly their naturally smooth color transition, as well as their crystal structure, which differed from smooth glass. The uneven surface of the quartz crystals deflects light in several directions and therefore appears softer than light deflected by freshly cut glass. By using this optical difference and adding areas that are partially transparent, with a matte or gently lustrous surface, the artist intentionally enriched the mosaic’s expressive power. Quartz pebbles are used in other soft details, such as folds in the velvet cloaks of St. Wenceslas and St. Sigmund, the fur hems of their vestments, and the clouds under the apostles. Here, the sections composed from white quartz pebbles are almost identical in color to the white smooth glass tesserae in the surrounding areas, but they differ significantly in structure and luster (see pl. 20). In addition to quartz, the mosaic contains small, opaque, uniformly cut white limestone pebbles. These are found in the whites of eyes, upper arches of some halos, and faces in the middle panel. The
whiteness of these smooth stones is very bright and warm in comparison to the cool greenish white of the glass. These white stones were used to broaden the mosaic’s range of colors and to create, especially in the facial nuances, a desired luminous accent complementing the deflected whiteness of warm quartz and cool glass.

Use of Tesserae in the Mosaic and Differences among the Three Panels  It is interesting to note that a different type of glass was used for the gilded tesserae in the background of the middle and lateral panels. The middle panel has red glass under the gilding, whereas the other panels have dark blue base glass. Different colors of the base glass under the gilding were clearly intended by the artist. The color of the glass tesserae in the gilded mosaic background creates a hierarchy in the imaginary space of the work. The central motif of the heavens is the most important and has a red base glass that provides a warmer glow to the gold, while the two-side motifs linked with the earth have instead a cooler-toned gold given by the blue base tesserae in the background. The background behind the “secular” figures of Charles IV and his wife is a midrange blue and was never gilded.

Another, less apparent difference is the way in which the figures are composed. In the side panels, larger tesserae and stones are often used in the facial features and the color shading is simple, graded only by the saturation of the warm tones of quartz. Olive green and cool white tesserae, laid next to the warm tones of the quartz and bright white limestone, expressively model the face and body of Christ. But on the faces and hands of the figures on the side panels, these only trace facial outlines. The difference cannot be explained only in terms of the hierarchy of figures; for example, the composition of the faces of the angels surrounding the mandorla, where only a few hundred stones and glass tesserae create an expressive and complete rendering of a face—from green shadows to brightest white accents—that is more refined than the simpler composition of the faces of the Virgin Mary, St. John the Baptist, and an angel helping a resurrected man from his coffin. Here a simple flat drawing, only slightly contoured by a line of green glass tesserae, provides facial definition. The areas of the latter faces are filled with quartz stones of limited color range, rarely complemented by whiter limestone. Nowhere is the cool white tone used to brighten the light color sections, or the red hues, which are the highest on the scale of warm colors, used on the faces in the central panel. The hair

is created primarily with two colors of fine, long, contrasting strips of rectangular tesserae. The curly hair of the apostle in the left panel is uniquely created from tiny brown-green spirals. (See pl. 7.)

In the left panel, blue has often been used to outline the figures. In the central panel, the outlines are black. In the right panel, the contours are rendered in both blue and black, with black dominant.

In conclusion, all three panels are almost identical with regard to the materials used; but the level of artistry varies. The technique in the central panel is of higher quality than that of the side panels. The Czech art historian Antonín Matějček first noted the different compositional quality of the central panel and side panels in his dissertation in 1915. He speculated that an Italian master had personally installed the central panel and that local helpers, who were not trained in the art of mosaic, had installed the side panels.

Physical Evidence of Previous Interventions

The mosaic was repaired several times during its existence. For a short time in the seventeenth century, it seems that it was covered with plaster for political reasons tied to the Czech throne’s brief embrace of Protestantism. Until the beginning of the nineteenth century, there are only indirect records documenting the repairs. None of the apparent changes on the mosaic can be credited, even hypothetically, to the much earlier repairs.

In conclusion, all three panels are almost identical with

sections that had become loose and fallen off were reattached and replaced in various ways. Historic records mention, among other things, stabilization of the mosaic with flat-headed nails and replacement of a fallen section with a fresco in 1837 (see chap. 7, fig. 12). All attempts to permanently consolidate the mosaic in situ were unsuccessful; by the end of the nineteenth century, the base plaster disintegrated, heavily damaged by rain and freezing temperatures and by water running off the roof. Rain and dripping water were washing off upper sections of the mosaic, which broke off under both windows and at the edges. In about 1890 there were attempts to hand-clean the mosaic’s surface using small sandstones and to revive the faded colors by using coats of varnish. Traces of sandstone cleaning have been covered over time and can be held responsible for the loss of most of the original gilding. Nothing is left from the wall paintings that replaced missing sections of tesserae or the nails that were supposed to reinforce the mosaic (see chap. 7,
In a few places, we can see nonoriginal materials applied to fill and replace the missing section.

The most apparent earlier repairs are made with large stones in the foreheads of two apostles in the left panel. These were clearly identified in the 1960s intervention (see chap. 6, fig. 10). Further evidence of previous repairs can be seen in the brown ceramic convex shards that someone used to fill the terrain background in the lower section of the left panel.

In the 1880s serious consideration was given to the idea of removing the entire mosaic and replacing it with a copy. In preparation, the mosaic was professionally photographed and copied by tracing over it in a 1:1 scale under the supervision of the architect Mokr. Most of these drawings have been preserved in the Prague Castle Archives and have great documentary value because they reproduce the most important parts of the mosaic, tessera by tessera (figs. 11, 12).

Since the mosaic had suffered extensive deterioration, it was divided into 274 sections and dismantled by Luigi Solerti, director of a mosaic firm in Innsbruck. The division lines were carefully planned to avoid the figures; when this was not possible, the lines would follow the edge of the drawing, such as the fold in a cloak (see figs. 4, 12). In the uniform background, the division lines were created horizontally and vertically to so that sections would be a manageable size. Before removal, each section was covered with several layers of facing paper. The mosaic was then cut into these sections. Along the division lines some tesserae had to be removed and some were probably lost. The speed of the mosaic removal proves the seriousness of the delamination from the supporting wall. The removal of the entire right panel took only half a day.11

The detached sections of the mosaic were stored for twenty years, in a nearby storage space under Vladislav
Hall. According to Viktor Förster, who was commissioned to restore the mosaic in 1910, this long period in storage caused further loss of the original tesserae. The paper facing had deteriorated on many sections, and several tesserae had become loose. Förster reported that the loosened tesserae in the section from the chest of Christ had completely dispersed. He also reported problems with the edges of several sections, such as a joint of the wing of an angel at the bottom right edge of the mandorla and on the face of Queen Elizabeth. Similar damage can be assumed at the edges of many other sections.

Before reinstallation most of the original mortar was removed from the back of the detached sections and a new pink-colored mortar applied. Then the paper facing was removed. Some of the lacunae were filled before reinstallation, but most replacement and reconstruction operations were performed in situ following the design documented in the painted copy created in 1890. Tesserae along separation lines were reinstalled using original and new tesserae, not always in a color that matched the surrounding areas. Many missing tesserae were replaced. Areas in the background of the three panels that had fallen off before removal of the mosaic were fully reconstructed using mainly old tesserae, or new ones prepared in Förster's studio (see figs. 4, 5). Plaster, into which the tesserae were inserted, simulated the original plaster in color and structure, except that it was somewhat darker and can easily be distinguished. Occasionally, on the front face of the mosaic, a fine cement-based thin gray mortar can be seen. This mortar was applied during reinstallation onto the backside of the sections and later leaked between tesserae through the remains of the old pink plaster, which still fills the seams (fig. 13).

Because of its strength, cement was used by Förster for reinstalling the mosaic. The cement has performed well for nearly one hundred years and the mosaic has not suffered the classic cement problems related to soluble salts. Adhesion problems have been virtually nonexistent up to the present day because Förster had deepened the foundation bed into the stone wall before reinstallation, so that it could hold all the foundation layers. The face of the mosaic is flush with the wall, so the water does not run between the wall and the plaster in which the mosaic is embedded. This arrangement remains effective. The mosaic's removal and its reinstallation remain the most drastic intervention in the almost
Conservation of the Last Judgment Mosaic

Six hundred years of its existence. Considering the mosaic's poor condition at the end of the nineteenth century, its removal and reinstallation solved the structural crisis. Clearly, both of these restoration treatments saved this precious artwork.

Later twentieth-century repairs were aimed primarily at removing the corrosion layer and did not cause any long-lasting changes in the mosaic's condition. During the extensive intervention in 1959–60, it was possible to make repairs in the gilding of the original tesserae. However, the new gilding of the background gradually disappeared as the protective lacquers disintegrated, and in the 1990s it became practically invisible.

The majority of new additions date from 1910. In addition to ensuring the structural stability of the mosaic, Förster's task was to repair any damage that had occurred as a result of the mosaic's removal. The goal was to rejoin the sections of the removed mosaic and replace missing tesserae in such a way that the mosaic could again give an impression of continuity. Förster achieved this by supplementing missing tesserae along the separation lines with a mixture of original and new tesserae, repairing heavily damaged areas, and reconstructing sections with missing background. He did not attempt, due to lack of supporting information, to reconstruct the sides of the upper border with acanthus decorations.

The mosaic currently measures 70 m². Originally, it was 15 m² larger. The lost area comprises the upper ornamental border, which did not survive. Only its middle fragment inside the rhombus around the vera icon has been preserved. The right part of the border with a similar rhomboid frame containing the nails of Christ's Crucifixion and the corresponding left side of the border vanished before the end of the nineteenth century. The preserved fragment of the upper border shows clear traces of extensive repairs, especially at the edges with acanthus decorations. Most of the original tesserae here remain in their original positions, but in addition to the original plaster, new plaster, into which the original and new tesserae were set, is often visible at the seams of the reinstalled areas. The vera icon itself is original, with no new tesserae or other obvious interventions, and its rhombus frame is also well preserved.

The extensively gilded background in the upper left and right panels is a result of the reconstruction in 1910 (see fig. 5). On the left panel, the entire upper section of the background, measuring approximately 2.2 m², was reconstructed, including the ornamental border. This reconstruction reaches up to the heads of the apostles and down to only a few centimeters above the Madonna's head. On the right panel, a similar reconstruction was performed on part of the background above and to the right of the window, approximately 50 cm from the upper rim. The total area of this reconstruction is approximately 1.2 m². For this reconstruction of the gilded background, mostly new tesserae were used that were gilded by employing the classic technique of gold foil baked under a layer of transparent glass. Förster wanted to mute the effect of the new gilding by combining a large number of original dark tesserae with new ones. In addition, on the left panel, the gold foil on the new tesserae was intentionally scratched before being baked in the glass sandwich.

There are many repaired and reconstructed areas in the borders of the mosaic. Partial reconstruction was performed in areas of the upper background in the middle panel, from the top to about the level of the third group of angel wings (see fig. 5). The separation lines are apparent, and many original red tesserae remained, but about the same number of tesserae, mostly original but blue, supplemented the missing tesserae. The heavily damaged background above the heads of the Virgin Mary and St. John the Baptist were similarly repaired. Here, the repairs are less obvious because the original and the majority of new tesserae, are blue. No other extensive repairs are apparent in the background. But there are many small repairs, and they appear even outside the separation lines. In some places, the separation lines are not limited to only one row of tesserae. It is obvious that after the nineteenth-century detachment, edges of many sections were disturbed and some tesserae fell off. A large number of newly installed tesserae, most often a combination of old and new gilded tesserae, are found mainly in areas where the separation lines cross. Newly installed tesserae are also more often found around cracks that kept opening in the same places over the centuries (see fig. 6). During repairs, preference was given to the original tesserae, which had been collected over the years as they fell from other sections. A small number of original tesserae still remain in the Archives of the Prague Castle. The original tesserae were preferred for repairs even if their color was not suitable. The small area in the green-brown background, near the left foot of the Archangel Michael, which is filled with blue tesserae, serves as an example (see pl. 4). Only rarely were the original, especially white tesserae, replaced with white stones, and seldom were ceramic shards used. Ceramic shards were not consistent with the materials...
used in Förster’s extensive and careful restoration and therefore must be evidence of an earlier intervention.

Relatively few repairs can be found in the figure motifs; more extensive reconstruction is the exception. Most apparent is the damage on the faces of two apostles in the second row of the left group, which was repaired with large pebbles. These additions come from the time before the mosaic’s removal, and Förster intentionally respected them. He reconstructed (from original material) a portion of the head of an apostle who stands at the top of the left group and the lower half of the face, neck, and chest of Queen Elizabeth. Both of these reconstructions are identifiable; the second stands out because Förster used only new glass instead of the original combination of quartz and glass.

The reconstruction performed on Queen Elizabeth’s figure is also the most extensive of a figure motif (fig. 14).
No larger reconstruction can be noticed on Christ's chest, where, according to one reliable source, the section broke during removal, dispersing the tesserae. It can be assumed that in this case no large area disintegrated, and only a number of tesserae became detached from the paper used for facing, which were reattached while still in the studio, and thus the section was stabilized. All the tesserae that were reattached in this way to their original spot were then reinstalled into cement-based plaster, which was in many places pushed up along the sides of tesserae. Some small-area reconstructions can also be seen in the wings of angels. The largest is on top of a wing of the right angel under the mandorla. The transfer of the mosaic caused damage to the outline of the back of the devil emptying the sarcophagus, the finger and contour of the body of the man lying in the coffin, and the contour of a child being carried away by an angel, as well as other smaller defects.

**Plaster Colors**

The first criterion for determining the originality of the composition is the glass tessera that was used. The degree to which we can be certain about visually distinguishing, with some practice, original glass from newer glass, depends on color. We can almost certainly distinguish the original glass from new in the case of original tesserae that do not appear in a range of color mutations or in the case of seedy glass pastes with varying hues. But the majority of glass fits this description. Sometimes an error can be made in the case of homogeneous glass and glass in varying hues, such as red or very dark black or blue, where oxidation of the glass surface has created difficulties in detecting any such difference. However, even absolute certainty about the originality of the tesserae does not provide certainty about the originality of their installation, since they could have been installed in their present location during one of the later repair interventions. Therefore, the decisive criterion for determining the original composition is the quality and homogeneity of the plaster in the seams between the tesserae. The original plaster is pink with clearly visible chips of crushed brick. It can be readily distinguished from the darker pink plaster that Förster used for reinstallation. Clearly different is the gray to gray-white cement plaster used before the final reinstallation to reattach the loose tesserae to the removed sections of the mosaic and which was often pushed up between tesserae. In other areas we can see individual tesserae that were inserted into standard, ocher-colored plaster. The presence of light lime and sand plaster can also be confusing. At one time this was applied in small amounts over the tesserae and particularly over smaller pebbles to stabilize them. They protruded too much from the original pink plaster and were in danger of falling off. This type of stabilization applied on top of the tesserae can be found also in the face of Charles IV and elsewhere. At first sight, this plaster can cast doubts on the originality of the composition thus treated. In the lower part of the left panel, traces can be seen of an unfortunate attempt in the second half of the 1950s to cover seams with cement.

**Mosaic Authenticity**

The distinction of reconstructions and repairs, based on detailed examination of glass and plaster conducted by a specialist very familiar with the mosaic, can be considered relatively objective. New findings employing this method are consistent with statements about the mosaic's previous interventions recorded in the Annual Report of the Union for Completion of St. Vitus Cathedral after the work was completed in 1910. Matějček discussed in detail the originality of the mosaic's composition in his 1915 dissertation. He based his hypothesis on evaluation of the composition from the perspective of art and history.

In accordance with our observations, Matějček mentions repairs in the faces of two apostles and in the face and chest of Queen Elizabeth. On the right panel, he notices damage on the figure of a devil searching through the coffin and repairs above the arcade arch. A close-up inspection made during our conservation project did not reveal other hypothetically nonoriginal details, mentioned by Matějček's contention that there is evidence of intervention on the back of a man carrying the lid of his coffin, on the figure beneath him, on an angel carrying one of the resurrected and his cloud, St. Peter's hand with a key, and clouds under the apostles on both sides. Even the cloak draping the herald angels on the middle panel seems to Matějček to contain Baroque elements that are not consistent with the fourteenth-century style. He finds traces of renovation in the portrait of Charles IV and in the bottom section of the ground supporting the saints. Based on an old record and an evaluation of styles, Matějček also considers the inscription bearing the names of saints not authentic. In our detailed examination of the mosaic's glass and plaster, we found no supporting evidence for these hypothetical reconstructions.
These areas are mostly well preserved, composed from original tesserae or quartz pebbles with intact plaster in the seams. Perhaps some doubts can be raised by the presence of whitish plaster between tesserae in Charles’s face. However, this plaster does not provide evidence that the portrait was reworked, since it is applied over the original pink plaster simply to reinforce the cohesiveness of the original composition.

**Originality of the Inscription**

Finally, let us consider the question of the originality of the inscription band bearing the names of Czech patron saints, which is set beneath the kneeling saints in the middle panel. Occasionally, a debate is revived regarding the originality of the inscription, on the basis of the Guidebook to St. Vitus Cathedral by L. Glückselig, published in 1855. At the end of the one-page appendix dedicated to the mosaic, Glückselig mentions in one sentence a repair performed by Eduard Gurck in 1837, and he claims that a new inscription, drafted by Hanka, was added under the middle panel. This claim attracts attention because Hanka is a Czech patriot and scholar known as the author of one of the forged medieval manuscripts that so stirred up the Czech cultural and political scene in the second half of the nineteenth-century. The material of which the inscription is composed does not provide any evidence of remaking or inauthenticity. The inscription is still well preserved. The black glass tesserae of letters as well as the white glass tesserae in the background are, with very few exceptions, undoubtedly original. The original pink plaster in the seams outside the transfer separation line is intact.

A natural explanation for the discrepancy between the apparent authenticity of inscription material and the claim about the addition of a new inscription is that Glückselig was in fact not referring to the inscription of saints’ names, which is part of the middle panel, but to another inscription that was added below the mosaic, somewhere on the wall between the pillars of the arcade in 1837. This new inscription on a stone plaque described the mosaic’s history and its repair by Gurck and was later removed. The existence of this inscription and its wording is documented in other written sources. This explanation is also logical in the larger context of Glückselig’s writing, because immediately before he mentions the repair in 1837 and the new added inscription, he concludes his description of the mosaic with this sentence: “The old inscription under the middle panel reads: Sc. Procopius. Sc. Sigismundus. Sc. Vitus. Sc. Wenceslas. Sc. Lodomilla. Sc. Adalbertus.” Honsatko quotes the same inscription in 1825 exactly the same way, as we know it today, including an atypical spelling for St. Ludmila. It does not make any sense to posit a connection between the mention of a new inscription and this unchanging text, described even by Glückselig as old.

**Condition of the Mosaic**

When the project started it included an assessment of the mosaic’s condition. The plaster layers were basically in good condition, and the adhesion to the foundation was good. In some places the plaster sounded hollow when tapped, but nowhere did it move or threaten to fall off. The mortar between the tesserae was also sound, probably because it had been reinforced by previous conservation treatments. There were no larger cracks in the middle panel. In the entire middle panel, only a few tesserae were missing.

On the right panel, there were only a few narrow cracks under the window, in the middle panel and above the arch. These cracks did not endanger stability, but a few tesserae had become loose in their vicinity. On the entire right panel, only a few tesserae were missing along the cracks, and on the left side in the terrain background (see fig. 6). Structurally, the left panel was the most damaged, with several deep cracks starting near the base of the window, extending across the middle field, and continuing toward the top and sides of the portal arch. The widest crack stretched across the middle of this panel, above the arch. The cracks were old and had been documented in the earliest photographs (see chap. 7). They were repaired several times in the past without lasting success. These cracks, which were probably caused by the micro-motion of the building foundation, permeated through the entire thickness of the walls and cannot be permanently closed. According to Petr Chotěbor, head of the Art Collection of the Prague Castle, expert static evaluations were repeatedly conducted confirming the static safety of the mosaic. In some places around the cracks, the tesserae became loose, and the filling mortar, made from classic, less elastic materials, gradually disintegrated. As with the other panels, the total number of missing tesserae on the left panel was estimated to be only in the dozens.

**Corrosion**

The surface of all colored glass tesserae was covered with corrosion products. The chemical composition of glass with
a high potassium and calcium content enables cations of these minerals to leach out in water. Their consequent reaction with carbon dioxide in the air and even faster reaction with sulfur dioxide results in the creation of complex potassium and calcium salts whose main component is gypsum. The crystals of the corrosion salts adhere to the surface of the glass and gradually create an all-encompassing gray layer. The extent of the corrosion varies according to the color of the glass. Four levels of corrosion were defined and recorded (see fig. 2). A compact dense white layer of corrosion appears on dark glass; compact brown corrosion with an upper white porous layer appears on white glass; and pink-brown with an upper white layer covers light blue glass. Some colors, such as yellow and green, suffer minimal corrosion. Red glass tesserae with gilding are also minimally affected. The red color remained visible through the thin corrosion layer, looking like grayish ice. It is interesting that the red tesserae show several distinguishable grades of corrosion, as if some batches of red tesserae corroded more than others. Other colors do not show such variations in corrosion. The newly replaced modern glass tesserae corrode substantially less, but even these are eventually covered with a continuous thin colorless coat of corrosion. At the start of the project, the mosaic was practically invisible due to the corrosion.

The original gilding had already disappeared in the past, and its remaining fragments were obscured by the corrosion of the top glass. However, the gilding applied in the beginning of the twentieth century was quite visible. In the upper section, the gilding created noticeable and defined areas and made the separation lines between the mosaic's detached sections much more visible. Repairs to the upper area of the background, above the angels around the mandorla, were also very noticeable. The mixture of corroded original red tesserae and newly replaced tesserae, mostly dark blue original and new gilded ones, provided an unpleasant chromatic balance of the artwork there. Gilding from the 1960s survived only sporadically as small shreds of gold foil embedded in scales of degraded remains of epoxy resin.

The glass mass of tesserae seemed to be well preserved under the corrosion and not affected by the environment. The glass quality fluctuates according to color. In addition to homogeneous and thoroughly fired glass, there are also many tesserae, especially light blue and light green, that are full of bubbles and surface indentations. This glass is much more vulnerable and much more difficult to clean. However, the inhomogeneous structure is part of the authentic substance of this glass, since this property was introduced during its manufacture and is a result of the technology of medieval glassmaking.

**CONCLUSION**

Every conservation project is an opportunity for an in-depth study and documentation of the work of art. The project for the conservation of the Last Judgment mosaic involved almost five years of research and three years of treatment. This gave the project team the opportunity to study the mosaic in great detail. It was possible to confirm the information provided by the historical documentation on the mosaic, in particular, to confirm that the numerous interventions did not have an impact on its authenticity. Signs of the physical history were interpreted by examining the materials composing the mosaic and the millions of colored glass tesserae and stone and the way in which they were laid down. Traces of original gold were identified, as were areas where the tesserae were relaid.

The observations made during the project were recorded in written, graphic, and photographic form. This documentation will remain an important record of the state of the mosaic during the years of the project and is essential to future evaluation of the mosaic's condition over time.

Documentation was carried out with a simple but efficient technology. As it is in digital form, it is a valuable and practical tool for the ongoing monitoring and maintenance of this important work of art. At the same time, digital technology can easily become obsolete, and therefore the information must be updated as technology advances and preserved in hard copy.

**NOTES**

1. The thick layer of corrosion on the glass made examination of the mosaic difficult. Information on materials and technique was collected after cleaning and removal of corrosion.
2. Photographic documentation was planned with the support of Rand Eppich at the GCI. It was carried out by Jaroslav Zastoupil of AFG, an independent Czech survey firm. One dozen tesserae served as "targets" for accurately measuring the mosaic with a total station or electronic distance measurement device (Leica TCR110). The mosaic and the targets were photographed with a large-format camera (Zeiss/Jena UMK 10/1318 with a Zeiss/Jena Lamegon 8/100 lens using Kodak Ektachrome 100S film). The negatives were then digitally scanned using a Leica scanner (DSW200 by Helava, pixel size 12.5 μm). The survey measurements of the targets were combined with the digital images to rectify or "stretch" the images to the real
measurements. The digital image was inserted in a CAD drawing and used as a base map for all the graphic information. This allowed measurements of the image and its condition as well as alignment of the images from the various phases of conservation.

3. Graphic documentation is a record of phenomena or other data created by superimposing symbols, patterns, or colors over a base map representation of the mosaic. In the past few years the GCI has developed a protocol for graphic documentation, and this was applied to the Prague project. For a description of the protocol, see Piqué 2000. The conservation team recorded graphically on site with markers over transparent overlays over photographic base maps. Sections of the image were printed on A4 paper in 1:8 scale, a manageable size for work on the scaffolding. The conditions recorded on the transparencies were then scanned, converted, and organized into the original survey file. (The transparencies were converted or vectorized using Hitachi raster-to-vector software.)

4. A sketch of this net (done during the detachment of the mosaic in the 1890s) is available in the Archives of the Prague Castle.

5. The original base plaster was lost during the mosaic’s detachment in 1890 and reinstallation in 1910. Castle records report that egg white was traditionally added to the mortar of important construction to increase solidity. This tradition has a rational explanation. Egg white, a natural hydrogel, can significantly lengthen the drying time of plaster and thus increase its strength through the gradual transition from slacked lime to carbonated lime. For the analytic results, see chap. 10.

6. Karel Heteš studied the chemical composition of the Last Judgment mosaic tesserae and compared them with glass tesserae from other sources. In 1958, in his seminal study, “On the Origin of Glass in the St. Vitus Mosaic in Prague,” he first hypothesized that the St. Vitus tesserae were produced locally. The historically documented development of the glass industry in the kingdom of Bohemia in the fourteenth century supports this hypothesis. For a detailed discussion of the results of historical and contemporary scientific studies of the glass used in the mosaic, see chap. 10 in this volume.

7. Another “historical” estimate that needs revision is the total number of tesserae used to make the mosaic. The 1950s calculation of one million is based on the assumption that each tessera’s side averages 9 mm; however, a great number of tesserae and stones are substantially smaller, so the total number of tesserae is probably a few hundred thousand more.

8. In the Middle Ages weight was often measured by the ratio of unspecified volumes, and no standards for various volume units existed. Oak ash was used as the basic flux in medieval central Europe. Glass was melted in iron pots in furnaces heated by wood under relatively low temperatures, approximately 1100°C. The molten glass was very inhomogeneous, insufficiently melted, and often cooled while still foamy.

9. A general description of tesserae manufacturing is in Mokr 1883. And see Strob 1900 for valuable general information on medieval glass production and medieval furnaces.

10. This estimate is based on an archaeological discovery in Bohemia of a 12-liter pot, which is considered the most common size. The actual number of batches was certainly much higher. Attempts were made by Czech archaeologists using a similar pot in experiments to reproduce glass with medieval methods, equipment, and materials. See Černá, Kirsch, and Brabenec 1993. This estimate is also in agreement with those contained in Strobl 1900. Strobl notes pots of about 5 liters (the entire output of a furnace when using more pots together is 40 liters), on the basis of the archaeologically proven dimensions of medieval furnaces. A pot of 12 liters is considered the average. Estimates of the necessary batch number are derived based on the known minimal number of batches.

REFERENCES


11. Unpublished detailed information concerning Förster’s work, including his written proposals for the treatment, his letters and notices, and the reports of the committee consultations are available in the Archives of the Prague Castle.

12. A border with small blue arches and crosses on the white background, at the edge of the areas described above, was also reconstructed. The left panel border was reconstructed using new tesserae. The right panel has a combination of original and new tesserae. Almost all of the red borders on the sides of the mosaic and above the arcade were reconstructed with new tesserae or a combination of old and new tesserae. The reconstruction above the right arch extends into the background at the top of the arch. Partly original areas with only a few repairs are found in the red border above the middle arch. The border of small crosses with is original for almost its entire length, except for minor repairs. In the middle panel, the original border of small crosses is preserved only along the upper ridge of the mosaic and it has many repairs. The areas of roughly triangular shape in the background under both windows, each approximately 1 to 3 m², were reconstructed, as were the narrow strips of color bordering both windows. These reconstructions were performed using mostly original blue tesserae with fragments of original gilding.

13. The Italian conservators Ambra Tomeucci and Bettina Elten of the Rome-based conservation group ARKE examined the mosaic in 1992.
mozaiky z let 1909–1910. Archiv Pražského Hradu. [Unpublished written records, proposals for work procedures, and letters by V. Foerster and records of the committee consultations of work in progress during reinstallation of the mosaic, 1909–10. Archives of the Prague Castle.]


Zápis o prohlídkě mozaiky a odběru 28 vzorků barev, iniciované Dr. Petásem, a laboratorní zpráva o chemických analýzách z r. 1958. Archiv Pražského Hradu.